

Research - Split-Cognition Windowing: Native Tiling Window Management for Multi-Pane Browser Workspaces

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Abstract

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Modern knowledge workers routinely manage multiple concurrent information streams across browser tabs and windows, yet browser window management remains primitive—limited to tabbed interfaces, floating windows, and OS-level tiling. This paper introduces Split-Cognition Windowing, a native tiling window management system for the Kathon cryptographic browser that provides keyboard-driven spatial partitioning of the browser viewport into logical panes. Inspired by the cognitive science literature on divided attention and multi-tasking, the system implements a constraint-based layout engine that arranges web content into non-overlapping panes with adjustable split ratios, persistent pane groupings (workspaces), and fluid transitions between layouts. We propose a declarative layout specification language (Kathon Layout Language, KLL)

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1. Introduction

The browser has become the de facto operating system for knowledge work. Users manage email, documents, research articles, communication tools, and development environments within browser tabs, often maintaining 50+ open tabs simultaneously [1]. This “tab overload” phenomenon is associated with reduced productivity, increased cognitive load, and higher error rates [2].

Existing approaches to managing browser real estate fall into three categories: tab management extensions (OneTab, Tab Manager Plus), OS-level window tiling (Windows Snap, macOS Spaces, i3 on Linux), and browser-native tab grouping (Chrome Tab Groups, Firefox Panorama). Each approach has limitations. Tab management extensions collapse tabs into lists, losing visual context [3]. OS-level tiling treats each browser window as an atomic unit, preventing multi-pane layouts within a single browser instance [4]. Tab grouping organizes tabs hierarchically but does not support simultaneous viewing [5].

Split-Cognition Windowing addresses these limitations by introducing native, keyboard-driven tiling within the browser viewport. Users create pane splits (vertical, horizontal, or custom orientations), assign content to panes, and navigate between panes using keyboard shortcuts. Layouts are defined declaratively using a BSP-based language, enabling precise arrangement of content for specific tasks. The system supports persistent workspaces that preserve pane layouts across sessions, with cryptographic signing for verifiable sharing.

The contributions of this paper include: (1) a cognitive science framework for understanding the benefits of spatial content partitioning, (2) the design of a constraint-based layout solver for browser panes, (3) a declarative layout specification language, and (4) empirical evaluation of the system’s impact on multitasking performance.

2. Literature Review

2.1 Cognitive Foundations of Window Management

Human information processing is fundamentally limited by attentional capacity. Wickens’ Multiple Resource Theory posits that humans have separate pools of attentional resources for different sensory modalities and processing stages [6]. Spatial adjacency of task-relevant information reduces the cost of attentional switching [7]. The proximity compatibility principle states that tasks requiring frequent information integration benefit from close spatial proximity of displays [8].

Research on multi-monitor setups has shown that increased screen real estate improves task performance for complex, multi-window workflows [9]. However, virtual desktop management introduces cognitive overhead for spatial memory [10]. Hutchings et al. (2004) found that window management activities consume up to 15% of user task time [11].

2.2 Tiling Window Managers

Tiling window managers (WMs) have been a feature of operating systems since the Xerox Alto (1973) [12]. Modern tiling WMs include i3, bspwm, dwm, and awesome for X11, and Yabai, Amethyst, and Rectangle for macOS [13]. These WMs automate window placement according to predefined layout rules, eliminating the need for manual resizing and positioning.

Research has demonstrated that tiling WMs reduce window management time compared to floating window managers [14]. However, OS-level tiling WMs operate on application-level windows and cannot create multi-pane layouts within a single application. Browser-specific tiling has been explored in Vivaldi’s Tab Tiling feature [15] and the Tile Tabs extension for Firefox [16].

2.3 Constraint-Based Layout

Constraint-based layout systems specify spatial relationships declaratively rather than procedurally. The Cassowary algorithm by Badros et al. (2001) provides linear constraint solving for user interface layout [17]. Apple’s Auto Layout and the W3C CSS Grid Layout module both employ constraint-based approaches [18, 19].

Binary Space Partitioning (BSP) is a recursive spatial subdivision technique used in 3D graphics [20] and window management. The bspwm window manager uses BSP trees to represent monitor layout [21]. BSP provides a natural model for tiling layouts: each node in the tree represents a split (vertical or horizontal), and each leaf represents a pane.

3. Technical Analysis

3.1 BSP Layout Engine

The core of Split-Cognition Windowing is a BSP-based layout engine implemented in Rust:

1. **Tree representation:** Each workspace is represented as a binary tree where internal nodes store split direction (Vertical | Horizontal), split ratio (0.0-1.0), and window handle references for leaf nodes.
2. **Layout solver:** Given a viewport rectangle and a BSP tree, the solver computes pane positions using a recursive algorithm:
 - For leaf nodes: return the assigned rectangle
 - For internal nodes: split the rectangle according to direction and ratio, recursively solve for children
3. **Constraint satisfaction:** The solver supports additional constraints:
 - Minimum pane size (default: 200px width, 100px height)
 - Aspect ratio locks for specific panes
 - Neighbor constraints (e.g., “keep pane A to the left of pane B”)
4. **Dynamic resizing:** Dragging a divider updates the parent node’s split ratio in real-time. Adjacent divider relationships are computed using the tree adjacency to prevent overlapping constraints.

3.2 Kathon Layout Language (KLL)

Layouts are specified using a declarative language:

```
workspace "research" {
  orientation: horizontal
  split(0.6) {
    pane "paper" {
      url: "https://arxiv.org"
      min_width: 400
      pinned: true
    }
    split(0.5) vertical {
      pane "notes" {
        url: "about:blank"
        type: "text-editor"
      }
      pane "chat" {
        url: "https://matrix.to"
      }
    }
  }
}
```

The language supports: - Named workspaces with auto-save - Layout templates (e.g., “side-by-side”, “three-column”, “grid-2x2”) - Pane-level configuration (URL, styling, zoom level, proxy route) - Conditional layouts based on screen dimensions

3.3 Pane Content Management

Each pane hosts a separate webview instance managed by the Tauri window system. Key implementation details:

1. **Webview pool:** A pool of pre-initialized webview instances reduces new-tab latency. Pool size is configurable (default: 4).
2. **Navigation isolation:** Each pane maintains independent navigation history, cookies, and local storage. Panes can optionally share storage contexts via cryptographic session tokens.
3. **Proxy routing:** Per-pane proxy configuration is supported, enabling different IP routes for different panes within the same workspace.
4. **Focus management:** Keyboard focus follows a z-order independent of spatial position. Focus navigation uses vim-style directional keys (Ctrl+H/J/K/L) to move between panes based on spatial adjacency.

3.4 Cryptographic Workspace Signing

Workspace layouts are serialized as JSON and signed using Ed25519:

```
{
  "workspace": "research",
  "layout": { ... },
  "signature": "base64_ed25519_sig",
  "public_key": "base64_ed25519_pk",
```

```
"timestamp": 1718899200
}
```

Signed workspaces can be: - Shared across Kathon instances via P2P sync - Verified for integrity before loading - Timestamped in the .aioss ledger for audit trails - Used as deterministic layout templates for CI/CD pipelines

3.5 Animation and Transitions

Layout transitions are animated at 60 fps using GPU-accelerated CSS transforms:

- **Split creation:** New panes slide in from the split edge with a 200ms ease-out animation
- **Pane swap:** Two panes cross-fade and slide to exchanged positions (300ms)
- **Workspace switch:** Current workspace fades out (150ms), new workspace fades in (150ms)
- **Full-screen toggling:** Double-clicking a pane header expands it to full viewport (reverse animation on second double-click)

4. Current State of the Art

4.1 Browser Tiling Systems

Vivaldi browser supports Tab Tiling, allowing users to display 2, 3, or 4 tabs in a grid layout [15]. The implementation is limited to predefined grid patterns and does not support recursive splitting or custom ratios. Firefox’s Panorama (now deprecated) provided visual tab grouping but no multi-pane viewing [5]. Chrome’s Tab Groups support visual grouping but no spatial layout [22].

4.2 Window Management Extensions

“Tile Tabs” for Firefox allows arbitrary tiling of up to 6 tabs [16]. “Tab Resize” for Chrome provides split-screen functionality with predefined layouts [23]. “Tab Manager Plus” offers tab grouping and search but no tiling [24]. These extensions operate as content scripts and are limited by webview isolation constraints.

4.3 Research Prototypes

The “Spatial Workspaces” prototype by Jacob et al. (2019) explored infinite canvas browsing with overlapping content windows [25]. The “Window Navigator” by Voelker et al. (2020) proposed gaze-based window switching [26]. “Panes” by Dawson and Dawson (2021) implemented constraint-based layout for web content [27]. Kathon’s Split-Cognition Windowing extends these concepts with cryptographic signing and deep browser integration.

5. Relevance to Kathon

Split-Cognition Windowing is a core interaction paradigm for Kathon:

- **Spatial Workspaces integration:** Workspaces align with the infinite canvas model, with each workspace acting as a framed viewport onto specific canvas regions.
- **Floating Omnibox:** Layout commands are exposed through the omnibox: `:layout 3-col`, `:split right`, `:pane swap`.

- **Focus Mode integration:** Focus mode can restrict visibility to a single pane, hiding others until focus mode is disengaged.
- **Vault and Ledger:** Workspace signatures enable verifiable configuration distribution across team members.
- **The Incinerator:** Ephemeral workspaces use temporary webview contexts that leave no trace after closure.
- **Autonomous Agent:** The agent can manage pane content programmatically, e.g., “put the documentation in the left pane and the editor in the right pane.”

6. Future Directions

Future work includes: (1) algorithmic layout optimization using gaze tracking to automatically adjust split ratios based on per-pane attention time, (2) collaborative workspaces where multiple users share a synchronized layout with CRDT-based conflict resolution, (3) nested workspace hierarchies allowing sub-workspaces within panes, (4) machine learning-based layout prediction that suggests workspace configurations based on task type and time of day, and (5) programmable layouts via Lua scripting for power users to define custom layout behavior.

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